EXECUTIVE SUMMARY

The guidelines presented in this document are the result of Chapter 1229 of the Statutes of 1990 (AB 3588, Speier - see Appendix A) that required the Indoor Air Quality Program (now Indoor Air Quality Section) of the California Department of Health Services (CDHS) to "develop nonbinding guidelines for the reduction of exposure to volatile organic compounds (VOCs) from construction materials in newly constructed or remodeled office buildings." The originating legislation was the result of concern about increasing complaints of sick building syndrome (SBS). This is a situation in which building occupants report symptoms, such as mucous membrane irritation, headaches, stuffiness, lethargy, and drowsiness, and which the occupants associate with a building. Researchers have reported that VOCs play a role in many SBS complaints, particularly in new or newly renovated office buildings, which often have substantial amounts of building and furnishing materials that emit VOCs.

The guidelines consider building **construction materials** to include not only construction materials and products but also major furnishings, such as office workstations, installed as part of a building's overall architectural and interior design. In addition, the guidelines address those cleaning and maintenance materials and products, the use of which are directly associated with the building construction materials and products selected.

The guidelines do not cover many other potential VOC sources such as: (a) occupant activities; (b) office equipment; (c) cleaning and maintenance products (other than the ones directly associated with the building construction materials selected); and (d) biological contaminants. These can be significant VOC sources in buildings. In addition, the guidelines do not provide special design considerations for accommodating those building occupants who are especially sensitive to VOCs.

The guidelines provide the best currently available information on minimizing occupant exposures to VOCs from office building construction materials. It should be noted that information in this field is evolving rapidly. For example, a number of testing methods for various building materials (e.g., carpet and paints) are being developed and will become available in the next few years. Also many product manufacturers continue to reduce emissions from their products. While specific information may change, the general guidance presented here is based on general methods and procedures for evaluating, selecting, and installing new building materials and therefore will still be applicable as information evolves. The guidelines have been written primarily for application to office buildings of any size that use mechanical heating, ventilating, and air-conditioning (HVAC) systems. However, the guidelines can be applied to most building types such as mixed-use buildings (e.g. libraries and courthouses). In addition, elements of the guidelines can be applied to naturally ventilated buildings.

The guidelines are intended for use by building professionals such as architects, engineers, building contractors, product specifiers, interior designers, building owners and operators, and others interested in reducing VOC concentrations in new construction. The guidelines do not present any new methods or techniques; rather, they summarize the most significant information currently available on this subject. Finally, the guidelines are **non-binding** and have **no** regulatory authority

The guidelines recommend a five-step approach to reducing exposure to VOCs from building materials and products. These five steps are listed below.

Step 1. Evaluate and select low-VOC-impact building materials and products: This is the most critical step in minimizing human exposure to VOCs emitted from building materials and products. In order to assess the impact of emissions from building materials, the guidelines define a **low-**

VOC-impact building material or product as one that when installed in a building results in minimal or reduced exposure of occupants to VOCs that are emitted from the material or product. Note that this definition does not necessarily imply that a low-VOC-impact material is also low-VOC emitting. The evaluation and selection of these materials and products is a four-step process as indicated in Figure 1 and discussed next.

Task 1: identification of target materials and products based on estimated installed quantities, proximity of installed materials and products to occupied zones, adsorption characteristics of some materials, and identification of materials and products with known high VOC emission rates;

Task 2: collection of more detailed VOC-related product information on candidate materials and products using manufacturers' lists of Material Safety Data Sheets (MSDSs) (MSDSs typically contain information about a material's chemical contents as well as information on the potential adverse health and safety effects resulting from exposure to these contents), product specifications listing chemical contents, results of emissions testing data, and other sources such as lists of carcinogenic contents;

Task 3: evaluation of building products and materials based on MSDSs, reactive VOC contents, calculated chemical emissions using vapor pressures and mass transfer coefficients, results of emissions testing, and estimated indoor concentrations; and

Task 4: selection of building products based on MSDSs and/or emissions testing results as shown on Figure 2. Selection of products based on MSDSs alone is complicated by the lack of industry standardization of the reported information, and the fact that MSDSs are sometimes incomplete or inaccurate failing to list all potentially hazardous substances. Furthermore, selection of products based on comparison of emissions testing data of functionally equivalent building products requires consideration of the following issues:

a) there is lack of standard emissions testing and reporting methods for VOCs (a summary of existing testing methods is presented);

b) total volatile organic compound (TVOC) results for the same mixture of components analyzed by different methods can vary by a factor of two or more due to differences in sample collection methods, TVOC calibration methods, and data reduction and analysis;

c) accuracy of TVOC results depends on the mixture of compounds being analyzed;

d) variation in history, age, condition of the tested material, and in environmental factors (i.e., ventilation, air velocities, temperature, and humidity of tested material samples) can affect reported emission factors by several orders of magnitude; and

e) delivered materials may have emissions different from tested samples (an issue that is difficult to address unless random testing of delivered materials is performed after delivery).

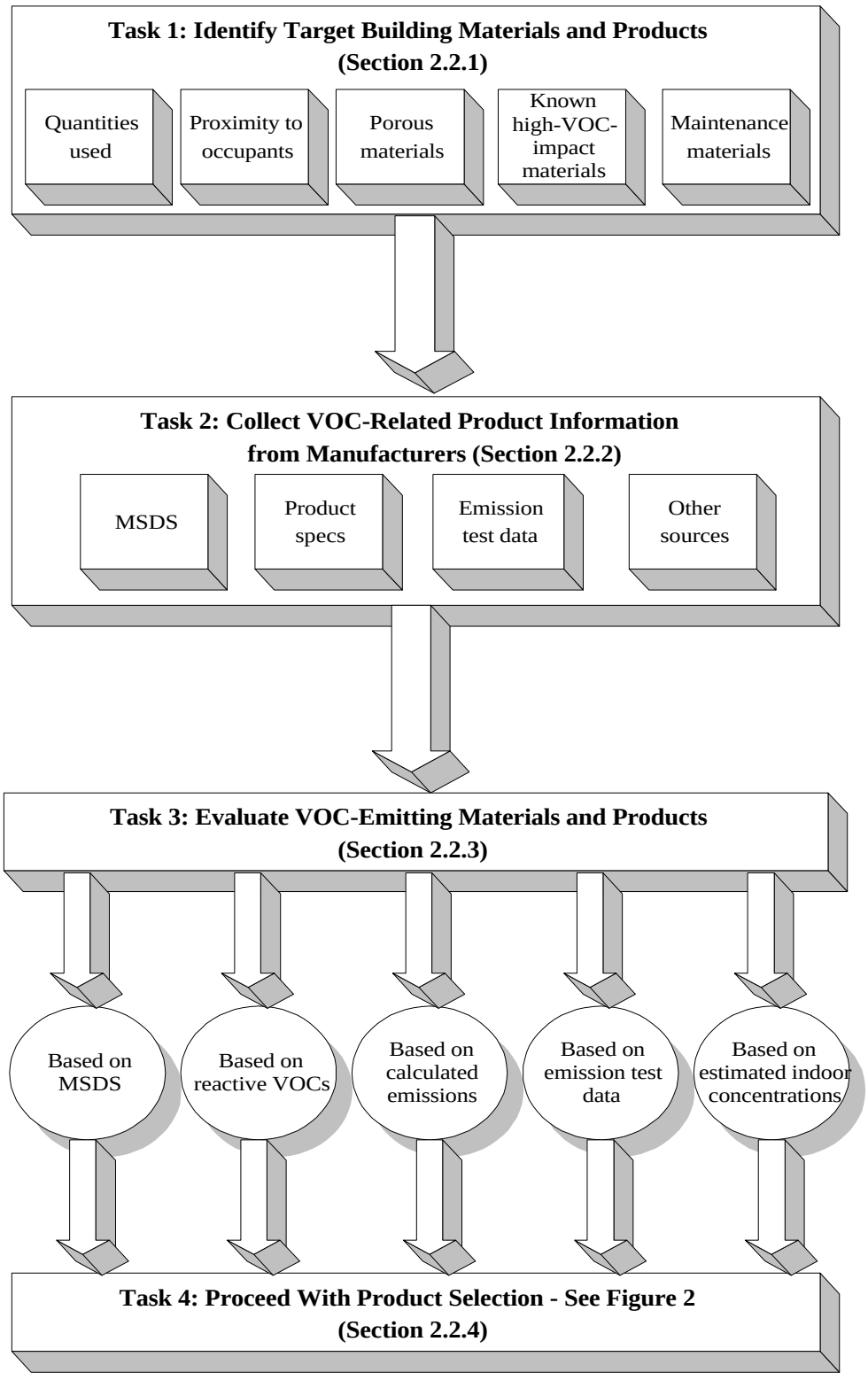

Figure 1. Four-Step Strategy for Evaluating and Selecting Building Materials and Products

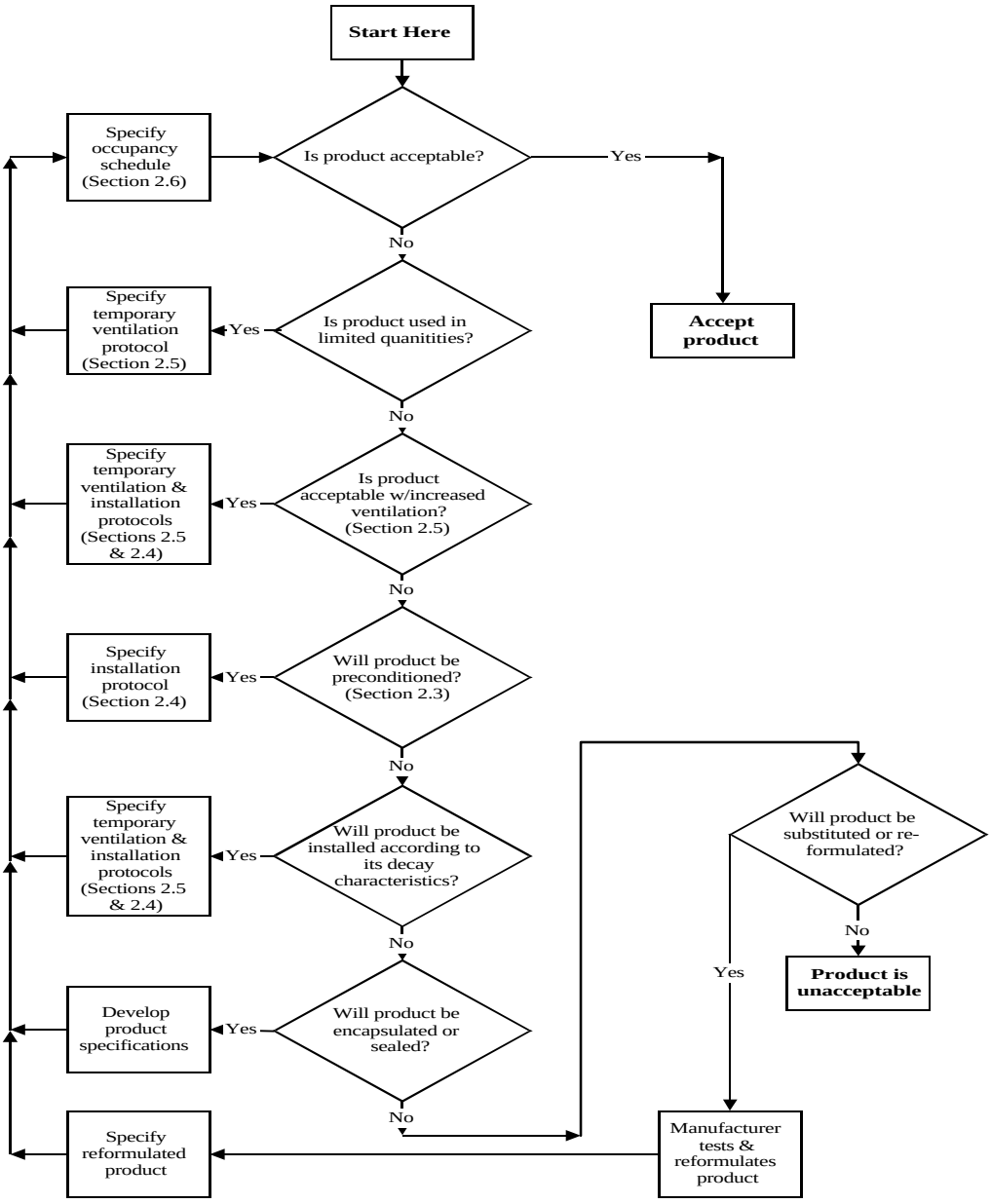

Figure 2. Flow Chart for Selecting Building Materials and Products

The above issues can be addressed before seeking bids from contractors and then should be verified in the submitted stage so that comparison of emission factors of functionally equivalent products can be made. Sample language for contract documents addressing the above issues is included in the present document. (Documents drawn in the pre-bid phase are referred to as **construction documents**.) Note that TVOC emission rates must be used to compare similar products with similar chemical compositions that have been tested using the same analytical methods.

Emissions testing data can assist a designer in comparing functionally equivalent products and making selections based on this comparison. However, it is difficult to select materials and products based on predictions of indoor VOC concentrations derived from emissions testing data because of the following uncertainties:

a) indoor VOC concentrations cannot be predicted accurately based on emissions testing data because of the time, space, and building dependency of such predictions (however, a simplified equation for estimating indoor concentrations from emission factors is presented); and

b) even if VOC concentrations could be predicted accurately based on emissions testing data, interpretation of indoor VOC concentrations would be difficult due to lack of health-based guidelines for most indoor pollutants found in non-industrial indoor environments. (A summary of existing guidelines for selected VOCs is presented as well as a survey of existing product labeling programs in the United States and Europe.)

Because of these complex issues, the guidelines focus on selecting building construction materials with low emission rates rather than on attempting to meet specific concentrations. It is important to note that considerations other than VOC emission rates may need to be made as part of the selection process of building materials. These considerations may include: acoustical properties, comfort properties, local building codes, architectural qualities, durability, warranty, and maintainability. (Note that the remaining four steps also have been incorporated in Figure 2.)

Step 2. Pre-condition certain materials to minimize VOC emissions after installation: This step includes conditioning of materials at the manufacturing or assembly facility, at a "bonded" warehouse with appropriate ventilation, or in a dry, well-ventilated area other than the one where the materials will be installed, until emissions have been reduced. Examples of these materials include office furniture and carpeting. Note that storage of certain materials after manufacturing is unavoidable especially in cases of special production orders or large quantities. For example, in the case of carpeting for a large-size building, there may be a time lag of several months between production and delivery of the product. In such cases storage is unavoidable and specifying a dry, well-ventilated space may not add a considerable cost to a project. There are no field data demonstrating the minimum length of time needed to effectively pre-condition various building products.

Step 3. Install building materials and products based on their VOC emission decay rates: This step involves the phased installation of building materials and products based on their emission and adsorption characteristics. Typically **wet** products such as paints, adhesives, and taping and deck leveling compounds should be installed first. Wet products are typically characterized by very high initial emissions followed by much lower emissions. This is because most solvents and other chemicals in wet products are emitted for a few hours or days after installation.

Porous materials, such as carpets and fabric-covered office dividers, should be installed last. This technique minimizes adsorption by porous materials of the VOCs initially emitted by wet products and subsequent re-emission at a later time (a process known as the **sink effect**).

Step 4. Ventilate a building during and after installation of new materials and products: The maximum amount of outside air should be provided during and after installation of VOC-emitting materials for the maximum amount of time feasible (this process is known as a building **flush-out**). There are no data on the recommended duration for building flush-outs, but a conservative approach is to flush-out as long as economically feasible, but not less than continuously (i.e., 24 hr) for seven days. It should be noted that the maximum amount of ventilation provided by an HVAC system may be limited not only by the system's capacity but also by the temperature and humidity of the outdoor air. Special procedures during partial building renovation/remodeling (i.e., completely isolating the air between occupied areas and areas under construction) should be followed and are discussed. The guidelines summarize and encourage compliance with ASHRAE's recommendation on **HVAC commissioning** (i.e., a process that ensures that the performance of an HVAC system meets design parameters) in order not only to minimize exposure to VOCs but also to improve indoor air quality during the life of a building.

Step 5. Delay occupancy until VOC concentrations have been reduced adequately: Because VOC concentrations are highest during and immediately after construction, it is important to allow sufficient "flush-out" time before occupants move in. Air samples can be taken to verify that indoor VOC concentrations have been reduced sufficiently prior to occupancy. It should be noted that: (a) guidelines exist for only a few VOCs; (b) there are no standard testing methods for TVOCs; and (c) existing guidelines for TVOCs are not widely accepted. However, TVOC concentrations can be used to compare a building's indoor air with measurements taken in other non-problem buildings.

A detailed economic analysis of all the costs associated with the above five steps is beyond the scope of the guidelines. However, some of these costs are discussed. Unfortunately there is very limited published information on this subject. Based on this limited information, it appears that the highest cost of reducing occupant exposure to VOCs is associated with emissions testing of building materials, especially when many products must be tested. The cost of testing individual products based on the **headspace** sampling technique ranges between $1,000 and $2,000, whereas the cost of testing large-size products, such as complete office workstations, in **environmental chambers** exceeds $5,000 depending on many factors such as test duration, number of test air change rates, number of samples tested, etc. Other costs, such as design fees, cost of building materials, cost of increased ventilation, and cost of delayed occupancy, also need to be considered. Limited data indicate that design fees are low, accounting for less than 1 percent of the Architectural/Engineering (A/E) fees of a project (A/E fees for high-rise office buildings typically account for between 4 and 6 percent of the construction cost). Although the cost of building materials account for a major portion of the construction cost (typically between 30 and 60 percent), their cost is usually independent of their emission characteristics (i.e., lower VOC emissions do not necessarily imply higher cost). Small premiums charged for some low-VOC-emitting materials are likely to be reduced or eliminated as demand for these products increases. Finally, other costs such those resulting from increased ventilation and delayed occupancy are project-specific. It is important for building owners and employers to realize that if poor indoor quality increases the absenteeism rate by only 2.5 percent (OSHA estimated this rate to be 3 percent) then the increased annual costs associated with this increased absenteeism rate is comparable to the cost of utilities or maintenance and operation of a building. Other economic impacts of improved indoor air quality also must be considered. These include reduced liability exposure, improved building marketability, reduced health care costs, lower operating costs, and increased occupant comfort

and productivity.

Other topics mandated by AB 3588 and discussed in the guidelines include the following:

1. Discussion of the appropriateness of mandatory regulations: Due to the limited information available for selecting low-VOC-impact materials and the lack of standard testing methods for building materials, consideration or development of mandatory regulations is inappropriate at this time. Compliance with the guidelines is encouraged on a non-binding, voluntary basis. Product manufacturers are encouraged to develop voluntary labeling programs as more standard testing methods for various building materials become available.

2. Discussion of the usefulness of formation of an ad hoc committee of professionals and other interested parties: The guidelines encourage the formation of a multi-disciplinary committee of professionals to further review the guidelines, to make recommendations for modifications, and to advise the CDHS on the practicality of the guidelines based on the field experience of the committee's members. In addition, the guidelines recommend the formation of a central repository for product emission information and current product regulations.

3. Discussion of a process known as building **bake-out**: This is a process designed to "artificially age" building materials and products by elevating the temperature of an unoccupied, newly constructed or remodeled building while supplying a fixed amount of ventilation, and flushing the building with the maximum possible ventilation after completion of the bake-out. Due to problems associated with this process and its questionable effectiveness, the guidelines do not recommend building bake-outs. Instead, the guidelines recommend selection and installation of low-VOC-impact materials and products followed by a building flush-out. However, some technical aspects of building bake-outs are discussed.